CIVIL AIR PATROL

INTRO TO SPACE

STK LESSON PLAN TWO:

TYPES OF ORBITS

PART II - STK SCENARIOS

This portion of the lesson plan illustrates the satellite concepts you have learned about so far. To do this, you will run four self-guided scenarios using STK/VO software. Each scenario will help you visualize the characteristics associated with one of the four basic satellite orbits described earlier.

The instructions below are a step-by-step guide to help you view and understand the scenarios.

SCENARIO ONE

Scenario One helps you visualize the characteristics of LEO satellites. These characteristics include:

- The relationship of a satellite orbit to the rotation of the earth.
- The relative speed of a satellite travelling in orbit.
- The satellite's sensor field of view size.

The scenario will illustrate these characteristics using **COSMOS_2326** orbital data. **COSMOS_2326** is a Russian Earth Resources Satellite, or EORSAT. To run the scenario, complete the following steps.

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1. Initialize STK VO by following the instructions in **STARTING AND USING SATELLITE TOOL KIT**
2. Load the file **Scenario\Lesson1\Leo\LEO_LP1A.sc**
3. Select the **VO** map**,** and maximize the screen.
4. Enlarge the earth until the North and South Poles just touch the top and the bottom of the screen
5. Select **RESET** if the orbit is not visible.
6. Position Australia at the seven o'clock position.
   - You are viewing the **COSMOS_2326** satellite.
   - **NOTE:** You can view details of the orbit by highlighting **COSMOS_2326** in the **Satellite Tool Kit** window. Select **PROPERTIES, BASIC**, and then **DESCRIPTION**. In this tab, information like official name, mission, orbit size, and orbital parameters are displayed. Detailed information on what each orbital parameter means will be presented in future lessons. When finished with the review of description, cancel out by selecting **X**.
7. Select **START**
   - First observe the rotation of the earth from west to east. Remember, it takes approximately 24 hours for the earth to complete its rotation. By comparison, a LEO satellite takes approximately 90 minutes to complete its orbit. In this case, the **COSMOS_2326** satellite takes 92 minutes for one orbit. As a result, the effect of the earth's rotation gives the appearance the **COSMOS_2326** orbit is shifting to the west. However, the reality is the orbit does not move, the earth is spinning underneath the orbit.

8. Select **PAUSE,** then **RESET,** and finally **START**.

   At time **14:17** the **COSMOS_2326** satellite comes into view.

   At time **14:39**, select **PAUSE.**

   - Observe where the satellite is in relation to the land mass. It is between South American and European continents. You may need to rotate the earth to see it.

9. Resume the scenario by selecting **START.**

   At time **16:15** select **PAUSE**.

   - The scenario time is at a simulated 92 minutes later. The **COSMOS_2326** satellite is in the same position in the orbit, but it is over a different point on the earth. Eventually, over a period of a day, the earth will rotate under the satellite's orbit to the original starting position.

10. Select **RESET** and then **START.**

    - Observe the red cone. The cone represents the satellite's field of view from a low earth orbit altitude. Remember, compared to a HEO, GEO or MEO, the FOV of a LEO satellite is smaller.

    At time **16:10** select **PAUSE**.

    - Note the **COSMOS_2326** satellite passes directly over the ground observer position. During this time, the ground station can communicate directly with **COSMOS_2326**.

11. Select **START**.

    At time **17:42** select **PAUSE**.

    - A simulated time of 92 minutes has elapsed. Where is the satellite? The cone, representing the satellite's FOV, is no longer passing over the observer

position. Therefore, the ground station cannot communicate directly with **COSMOS_2326**.

12. Select **START** and view the scenario as often as needed. When complete select **PAUSE**. Close out according to the instructions in **STARTING AND USING SATELLITE TOOL KIT.** Do not save the file.

SCENARIO TWO

Scenario Two helps you visualize the characteristics of MEO satellites. These characteristics include:

- The relationship of a satellite orbit to the rotation of the earth.
- The relative speed of a satellite traveling in orbit.
- The satellite's sensor field of view size.

The scenario illustrates these characteristics using **GPS_03** orbital data. **GPS_03** is one of 24 satellites in the GPS constellation providing precise timing data for position location.

1. Open file **Scenario\Lesson1\Meo\MEO_LP1A.sc**.
2. Select the **VO** map and maximize the screen.
3. Select **RESET.**
4. Reduce the size of the earth until the entire orbit (depicted in red) is in view.
5. Rotate the Earth until Africa and Central Asia Continents in center view.
    - You are viewing the **GPS_03** satellite orbit.
    - **NOTE:** You can view details of the orbit by highlighting the **GPS_03** icon in the **Satellite Tool Kit** window. Select **PROPERTIES, BASIC**, and then **DESCRIPTION.** In this tab, information like official name, mission, orbit size,

and orbital parameters are displayed. Detailed information on what each orbital parameter means will be presented in future lessons. When you have finished reviewing this data cancel out by selecting **X**.

6. Select **START.**

   - Observe how slowly the MEO **(GPS_03)** satellite moves in its path. It takes approximately twelve hours to complete one orbit. Mathematically, a MEO satellite will complete two orbits for every one earth rotation. In other words, it will take two passes before the satellite is in view of the original earth position due to the earth's rotation.
   - Observe the satellite's field of view from this altitude. Comparatively, it is much larger than the LEO satellite's FOV. Consequently, a person on the ground will see the satellite for a longer period of time. Similar to a LEO satellite, a MEO satellite does not provide continuous coverage.

7. Select **PAUSE** and **RESET.**

8. Review the scenario as often as needed. When complete select **PAUSE**. Close out according to the instructions in **STARTING AND USING SATELLITE TOOL KIT.** Do not save the file.

SCENARIO THREE

Scenario Three helps you visualize the characteristics of HEO satellites. These characteristics include:

- The relationship of a satellite orbit to the rotation of the earth.
- The relative speed of a satellite travelling in orbit.
- The satellite's sensor field of view size.

To run the scenario, complete the following steps.

1. Open file **Scenario\Lesson1\Heo\HEO_LP1A.sc**.
2. Select the **VO map** and maximize the window.
3. Select **RESET.**
4. Orient the North American continent to the twelve o'clock position.
5. Select **START**.

   At time **14:30**, select **PAUSE.**

   - The satellite is now visible and is just beyond the perigee point in its orbit. Observe the satellites FOV. It is relatively small. Continue with the animation by selecting **START**.

   At time **21:30**, select **PAUSE**.

   - The satellite is nearing the apogee point as it slows down in its orbit. Also observe the FOV cone size. It will be at its largest diameter as it peaks at apogee altitude.
6. Select **RESET** and **START**.
7. Run the entire scenario without pausing.

   - As a reference point, observe how much of the U.S. is in the satellite's field of view. It covers the U.S. a large percentage of time, but its coverage is not continuous

8. Run the scenario as often as needed. When complete select **PAUSE.** Close out according to the instructions in **STARTING AND USING SATELLITE TOOL KIT.** Do not save the file.

SCENARIO FOUR

Scenario Four helps you visualize the characteristics of GEO satellites. These characteristics include:

- The relationship of a satellite orbit to the rotation of the earth.
- The relative speed of a satellite travelling in orbit.
- The satellite's sensor field of view size.

The scenario illustrates these characteristics using INTELSAT orbital data. INTELSAT is global commercial communication satellite. To run the scenario, complete the following steps.

1. Open file **Scenario\Lesson1\Geo\GEO_LP1A.sc.**

2. Select the **VO** map and maximize the screen. If the orbit is not visible, select **RESET**.
3. Orient the globe so that the North American continent is at the 11 o'clock position.
4. Zoom out so you can see the entire GEO orbit.
   - You are viewing the **INTELSAT_2D** satellite orbit.
   - **NOTE:** You can view details of the orbit by highlighting **INTELSAT_2D** in the **Satellite Tool Kit** window. Select **PROPERTIES, BASIC**, and then **DESCRIPTION**. In this tab, information like official name, mission, orbit size,

and orbital parameters are displayed. Detailed information on what each orbital parameter means will be presented in future lessons. When you have finished reviewing the description, cancel out by selecting **X**.

5. Select **RESET** and then **START.**

   - Observe the field of view. Compared to the lower altitude orbits, the field of view is large and covers nearly one-third of the earth. As the **INTELSAT_2D** moves around its orbit, the FOV remains over the same geographic spot on the earth. It is because **INTELSAT_2D** is revolving at the same speed as the earth's rotation. Consequently, relative to the person on the ground, **INTELSAT_2D** is constantly in view, resulting in continuous coverage. Thus, an INTELSAT in a GEO orbit can transfer information to and from the satellite and a ground observer located within its FOV at any time necessary.
   - Inherent in the advantage lies a disadvantage. A spot on the earth looks smaller at this altitude. As observed in the scenario, the **observer** marker over the central US can not be seen at this altitude.

6. Zoom in on the globe until the **observer** marker can be seen. This action demonstrates that at greater altitudes, it becomes more difficult to see a spot on the earth as compared to lower altitudes.

7. Run the scenario as often as needed. When complete select **PAUSE.** Close out according to the instructions in **STARTING AND USING SATELLITE TOOL KIT.** Do not save the file.

Part III - Student Problem

This portion of the lesson plan provides an opportunity for you to apply the concepts you have learned in Part 1 and Part 2 by solving a problem.

Problem

You have been tasked to survey the volcano activity in Kabankalan, Philippines. Your requirement is to take volcanic temperature data readings once every three days. What type of orbit would be best suited for a survey mission? What would be the advantage/disadvantage to your mission by placing the satellite in your proposed orbit?

Proposed Solution

A remote sensing type satellite in a LEO would be best for meeting the requirements specified in the problem. A LEO satellite, as demonstrated in scenario one, will collect the data on the

volcanic activity at a minimum of once every three days. Since the LEO is closer to the surface of the earth, the sensors can collect the data more easily. Thus, the LEO altitude offers an advantage over the other type orbits.

Proceed with the following steps to visualize the proposed solution.

1. Load file **Scenario\Lesson1\Student_problem\LP1problem.sc** and
2. Select the **VO** map and maximize the screen.
3. Zoom in on the globe until the North and South poles touch the top and bottom of the window. Over the South American continent is the **TIROS_06** satellite in LEO.
4. Position the Australian continent at the five o'clock position.
   - North of Australia is Kabankalan, Philippines, the area to be surveyed.
5. Select **START**.

   At time **1 Jan , 00:55**, select **PAUSE**.
   - The weather satellite is in view of the volcanic activity over the city of Kabankalan. Resume the animation by pressing **START**.

   At time **1 Jan, 02:33** select **PAUSE**.
5. Approximately, one simulated satellite revolution has elapsed. The satellite can no longer view the volcanic activity. Resume the animation by pressing **START**.

   At time **1 Jan, 23:38** select **PAUSE.**
   - Nearly a simulated day has elapsed. The satellite is once again in view of the area. The cause of the shifting position is due to the earth's rotation.
6. Run the scenario as often as needed. When complete select **PAUSE.** Close out according to the instructions in **STARTING AND USING SATELLITE TOOL**

KIT. Do not save the file.